

Topic A3: Work Energy and Power Notes and Handouts

Question 1

A force of 10 N is applied to move a box 5 meters in the direction of the force. How much work is done on the box?

- A. 2 J
- B. 10 J
- C. 50 J
- D. 100 J

Question 2

Which of the following is a scalar quantity?

- A. Force
- B. Velocity
- C. Displacement
- D. Work

Question 3

A ball of mass 2 kg is raised to a height of 5 meters above the ground. What is its potential energy relative to the ground? (Assume $g = 10 \text{ m/s}^2$)

- A. 10 J
- B. 25 J
- C. 50 J
- D. 100 J

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Question 4

A car of mass 1000 kg is moving with a speed of 20 m/s. What is its kinetic energy?

- A. 2×10^5 J
- B. 2×10^4 J
- C. 1×10^5 J
- D. 1×10^4 J

Question 5

Which of the following statements about energy conservation is true?

- A. Kinetic energy can be converted to potential energy, but not vice versa.
- B. Energy can neither be created nor destroyed.
- C. Only potential energy is conserved in a closed system.
- D. Energy is always lost as heat in any transformation.

Question 6

a) Define the term "work" in the context of physics. How is it calculated? [2]

b) A force of 50 N is applied to a box, causing it to move a distance of 4 m in the direction of the force. Calculate the work done on the box. [2]

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Question 7

- a) Differentiate between kinetic energy and potential energy, providing an example for each. [3]
- b) A 5 kg object is lifted to a height of 10 m above the ground. Calculate its gravitational potential energy. (Assume $g = 9.81 \text{ m/s}^2$) [2]

Question 8

- a) Define "power" in terms of work and time. [2]
- b) If a machine does 600 J of work in 10 seconds, what is its power output? [2]

Question 9

- a) Explain the principle of conservation of energy. [2]
- b) A 3 kg ball is dropped from a height of 20 m. Calculate its potential energy at the start. [2]
- c) Using the conservation of energy principle, determine the kinetic energy of the ball just before it hits the ground. [3]

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Question 10

- a) Define Newton's second law of motion and explain its relation to work. [3]
- b) A force of 10 N acts on a 2 kg object, causing it to accelerate. Calculate the acceleration of the object. [2]
- c) If the object moves a distance of 5 m under this force, determine the work done on the object. [2]

Question 11

If a machine does 500 J of work in 10 seconds, what is its power output?

- A. 5 W
- B. 50 W
- C. 500 W
- D. 5000 W

Question 12

Which of the following best describes Newton's Third Law?

- A. For every action, there is an equal and opposite reaction.
- B. Force is equal to mass times acceleration.
- C. Objects in motion stay in motion.
- D. Work is force times distance.

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Question 13

A 60 W bulb is on for 2 hours. How much energy does it consume?

- A. 30 J
- B. 120 J
- C. 7200 J
- D. 432000 J

Question 14

A force of 15 N is applied to an object, but no work is done. Which of the following could be a possible reason?

- A. The object moved in the direction of the force.
- B. The object has a lot of inertia.
- C. The force was applied perpendicular to the direction of motion.
- D. The object has a lot of kinetic energy.

Question 15

Which of the following is NOT a form of energy?

- A. Thermal
- B. Elastic
- C. Friction
- D. Chemical

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Question 16

- a) What is the difference between average power and instantaneous power? [3]
- b) A machine does 2000 J of work in 8 seconds. Calculate its average power. [2]
- c) If the machine did 500 J of this work in the first 2 seconds, what was its power output during this time? [2]

Question 17

- a) Describe the relationship between work, force, and the angle at which the force is applied. [3]
- b) A 100 N force is applied to push a box a distance of 4 m at an angle of 30° to the horizontal. Calculate the work done by the force in the direction of motion. [3]
- c) If this work was done in 5 seconds, determine the power. [2]

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Question 18

- a) Define kinetic energy and state its formula. [2]
- b) A car of mass 1200 kg is moving with a speed of 20 m/s. Calculate its kinetic energy. [2]
- c) The car comes to a stop due to a constant braking force. Determine the work done by the brakes to stop the car. [3]
- d) If the car took 10 seconds to come to a stop, calculate the average power exerted by the brakes. [3]

Question 19

- a) Differentiate between gravitational potential energy and elastic potential energy. [3]
- b) A 50 kg object is lifted to a height of 10 m. Calculate its gravitational potential energy. [2]
- c) The object is then dropped and bounces back to a height of 5 m due to its elastic potential energy. Calculate the energy lost during the bounce. [3]
- d) Explain the principle of conservation of energy in the context of this scenario. [2]

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Question 20

- a) Define power in terms of work and time. [2]
- b) A motor does 5,000 J of work in 25 seconds. Calculate its power output. [2]
- c) If the motor operates at this power for 2 hours, determine the total work done. [3]
- d) Explain how the efficiency of a machine can affect its power output. [3]

Answers

1.

C. 50 J

Work is calculated as the product of force and distance in the direction of the force. $\text{Work} = \text{Force} \times \text{Distance} = 10 \text{ N} \times 5 \text{ m} = 50 \text{ J}$.

2.

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D. Work

Work is a scalar quantity as it only has magnitude and no direction.

3.

C. 50 J

Potential energy (PE) is given by $PE = mgh$. $PE = 2 \text{ kg} \times 10 \text{ m/s}^2 \times 5 \text{ m} = 100 \text{ J}$.

4.

A. $2 \times 10^5 \text{ J}$

Kinetic energy (KE) is given by $KE = 0.5 \times \text{mass} \times \text{speed}^2$. $KE = 0.5 \times 1000 \text{ kg} \times (20 \text{ m/s})^2 = 2 \times 10^5 \text{ J}$.

5.

B. Energy can neither be created nor destroyed.

This is the principle of conservation of energy.

6.

a) In physics, "work" is defined as the product of force and the distance over which the force is applied, in the direction of the force. It is calculated using the formula: $\text{Work} = \text{Force} \times \text{Distance}$.

b) $\text{Work} = \text{Force} \times \text{Distance} = 50 \text{ N} \times 4 \text{ m} = 200 \text{ J (Joules)}$.

7.

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a) Kinetic energy is the energy possessed by an object due to its motion. For example, a moving car has kinetic energy. Potential energy, on the other hand, is the energy possessed by an object due to its position or configuration. An example would be a stretched spring or an object held at a height above the ground.

b) Gravitational Potential Energy = $m \times g \times h = 5 \text{ kg} \times 9.81 \text{ m/s}^2 \times 10 \text{ m} = 490.5 \text{ J}$.

8.

a) Power is defined as the rate at which work is done or the amount of work done per unit time. It is calculated using the formula: Power = Work / Time.

b) Power = Work / Time = $600 \text{ J} / 10 \text{ s} = 60 \text{ W}$ (Watts).

9.

a) The principle of conservation of energy states that energy cannot be created or destroyed, only transferred or converted from one form to another. The total energy in a closed system remains constant.

b) Potential Energy = $m \times g \times h = 3 \text{ kg} \times 9.81 \text{ m/s}^2 \times 20 \text{ m} = 588.6 \text{ J}$.

c) As the ball falls, its potential energy is converted into kinetic energy. Just before it hits the ground, all its potential energy has been converted to kinetic energy. Therefore, its kinetic energy is 588.6 J.

10.

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a) Newton's second law of motion states that the force acting on an object is equal to the mass of that object times its acceleration ($F = ma$). When a force acts on an object over a distance, it does work on the object.

b) Acceleration, $a = F/m = 10 \text{ N} / 2 \text{ kg} = 5 \text{ m/s}^2$.

c) Work = Force x Distance = $10 \text{ N} \times 5 \text{ m} = 50 \text{ J}$.

11.

B. 50 W

Power is work done per unit time. Power = Work/Time = $500 \text{ J} / 10 \text{ s} = 50 \text{ W}$.

12.

A. For every action, there is an equal and opposite reaction.

This statement is the essence of Newton's Third Law.

13.

D. 432000 J

Energy = Power x Time = $60 \text{ W} \times 2 \times 3600 \text{ s} = 432000 \text{ J}$.

14.

C. The force was applied perpendicular to the direction of motion.

Work is done only when the force has a component in the direction of motion.

15.

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C. Friction

Friction is a force, not a form of energy. However, it can cause a transformation of energy, such as kinetic energy to thermal energy.

16 .

a) Average power is the total work done or energy transferred divided by the total time taken. It gives the power output over a period of time. Instantaneous power, on the other hand, is the power at a specific instant in time.

b) Average Power = Work / Time = $2000 \text{ J} / 8 \text{ s} = 250 \text{ W}$.

c) Power during the first 2 seconds = Work / Time = $500 \text{ J} / 2 \text{ s} = 250 \text{ W}$.

17.

a) The work done by a force is the product of the force, the distance over which it acts, and the cosine of the angle between the force and the direction of motion. Work = Force x Distance x $\cos(\theta)$.

b) Work = Force x Distance x $\cos(\theta) = 100 \text{ N} \times 4 \text{ m} \times \cos(30^\circ) = 346.41 \text{ J}$.

c) Power = Work / Time = $346.41 \text{ J} / 5 \text{ s} = 69.28 \text{ W}$.

18.

a) Kinetic energy is the energy possessed by an object due to its motion. Its formula is $KE = 0.5 \times m \times v^2$.

b) $KE = 0.5 \times 1200 \text{ kg} \times (20 \text{ m/s})^2 = 240,000 \text{ J}$.

c) The work done by the brakes is equal to the change in kinetic energy, which is $-240,000 \text{ J}$ (negative because the energy is being removed).

d) Power = Work / Time = $240,000 \text{ J} / 10 \text{ s} = 24,000 \text{ W}$.

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19.

a) Gravitational potential energy is the energy an object possesses due to its position in a gravitational field, while elastic potential energy is the energy stored in an object when it is stretched or compressed.

b) $GPE = m \times g \times h = 50 \text{ kg} \times 9.81 \text{ m/s}^2 \times 10 \text{ m} = 4,905 \text{ J}$.

c) The energy at 5m height = $50 \text{ kg} \times 9.81 \text{ m/s}^2 \times 5 \text{ m} = 2,452.5 \text{ J}$.
Energy lost = $4,905 \text{ J} - 2,452.5 \text{ J} = 2,452.5 \text{ J}$.

d) The principle of conservation of energy states that energy cannot be created or destroyed, only transferred or converted. In this scenario, the gravitational potential energy of the object was converted to kinetic energy as it fell, and then to elastic potential energy when it bounced, with some energy lost due to non-conservative forces like air resistance and internal deformation.

20.

a) Power is the rate at which work is done or energy is transferred. It is given by the formula $\text{Power} = \text{Work} / \text{Time}$.

b) $\text{Power} = 5,000 \text{ J} / 25 \text{ s} = 200 \text{ W}$.

c) $\text{Total work} = \text{Power} \times \text{Time} = 200 \text{ W} \times 2 \times 3600 \text{ s} = 1,440,000 \text{ J}$.

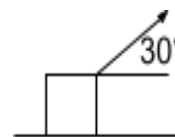
d) Efficiency is the ratio of useful output energy (or work) to the input energy. If a machine is not 100% efficient, some of the input energy is lost, usually as heat, and not converted into useful work. This means that even if two machines have the same power input, the one with higher efficiency will have a greater power output in terms of useful work done.

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Topic A3 – Work, energy and power **Formative Questions**

1. An 820-kg Smart Car has an acceleration of 1.5 ms^{-2} . What is the work done by the net force acting on the car if it travels 125 metres? 1. _____

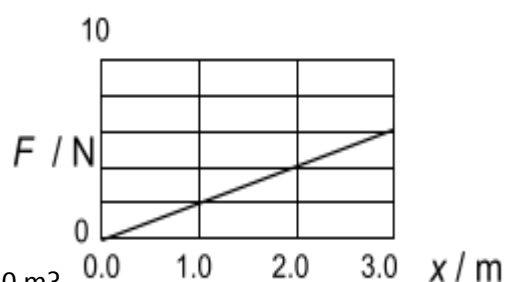
2. What is the work done by the 300N tension shown if it is used to drag the 250N crate 45 m across the floor at a constant speed?



2. _____

A variable force, shown in the graph below, acts on a 2.5-kg mass which is initially at rest.

3. What is the work done by the variable force whose from $x = 1.0$ to $x = 3.0 \text{ m}$? 3. _____



4. What is the kinetic energy of the mass at the position $x = 3.0 \text{ m}$?

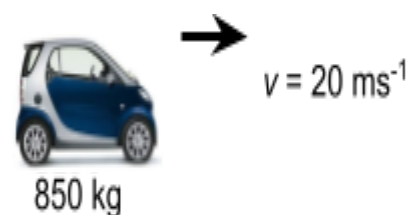
4. _____

5. What is the speed of the mass at the position $x = 3.0 \text{ m}$?

5. _____

The Smart Car shown in the picture has speed and mass as shown.

6. What is the kinetic energy of the car at this moment?



6. _____

7. If the driver suddenly applies the brakes and brings the car to a stop in 3.0 s, what is the work done by the friction force between the tires and the road surface? 7. _____

8. What is the average friction force during the braking action?

8. _____

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9. Suppose the car drives up a hill whose altitude is 45 m above the car's starting point. What is the change in potential energy of the car in going up the hill from its starting point?

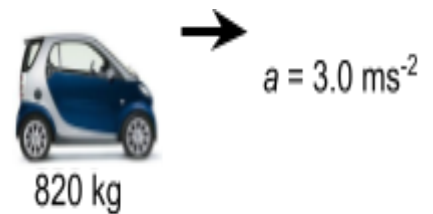
9. _____

10. If the car in the previous problem begins to slide down the ice-covered and (magically) frictionless hill, what will its speed be when it is at an altitude of 25 m? 10. _____

11. What will its speed be when it reaches the bottom of the hill? 11. _____

A Smart Car accelerates from rest as shown.

12. If the constant acceleration occurs over a distance of 50m, what is the work done by the car in accelerating itself?



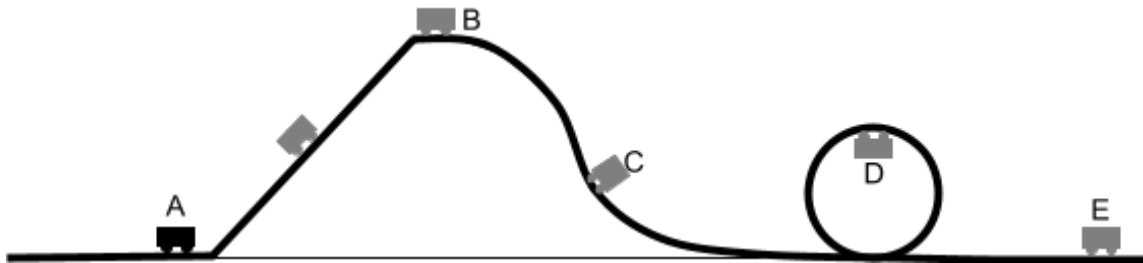
12. _____

13. How long does the acceleration take? 13. _____

14. What, then, is the average output power produced by the engine during the acceleration? 14. _____

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The Goliath is a new wooden roller coaster that allows the riders to go upside-down on the loop shown below. The starting height of the coaster is 95.6 m. The radius of the loop is 24.4 m. Riders board the cars at A. The car is drawn by a chain up to the point B and then released from rest. Gravity does everything from then on through the points C, D and E!



15. What is the change in potential energy of a typical loaded car having a total mass of 1520 kg as the chain pulls it from A to B? 15. _____
16. What is the kinetic energy of the car at D? 16. _____
17. What is the speed of the car at D? 17. _____
18. What is the kinetic energy of the car at E? 18. _____
19. What is the speed of the car at E? 19. _____

[Answers Here](#)